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Cooling System

Description of Invention

The invention relates to a cooling system, in particular for an internal combustion engine, the cooling system including a pump with an impeller for pumping liquid coolant, and a drive shaft which is driven by the engine.

Typically, the impeller is connected directly to the drive shaft of the engine, so that there is a direct relationship between the speed of operation of the engine and the speed of rotation of the pump impeller, i.e. as the speed of operation of the engine, and hence the speed of rotation of the drive shaft, increases, the speed of rotation of the pump impeller increases. In this case, the speed of operation of the pump cannot be controlled independently of the speed of the engine, and the pump will always be operated whilst the engine is running, regardless of whether or not pumping of coolant around a cooling circuit is required.

In order to provide a facility for controlling flow of coolant around the engine independently of the engine speed, it is known to provide an electrical clutch system between the drive shaft and the impeller of the pump, which is electrically activated in order to transmit drive from the drive shaft to the pump impeller by means of an electrical controller. A disadvantage of this system is that it is relatively complex, as it is necessary to provide electrical connections between the electrical controller and the clutch system, and thus the clutch system may not readily be integrated into an existing engine cooling system.

According to the invention we provide a cooling system for an internal combustion engine including a pump with an impeller for pumping liquid coolant around a cooling circuit, and a drive shaft, wherein between the impeller and drive shaft there is provided a clutch including first and second clutch members which are moveable into and out of engagement, to connect and disconnect drive from the drive shaft to the impeller respectively, by a

temperature sensitive device which includes a chamber in which there is provided a material which over a first, lower, temperature range is in a first state, and over a second, higher, temperature range is in a second state, the material changing volume when transforming from the first state to the second state to urge the first and second clutch members together to transmit drive, and wherein the impeller is constructed such that coolant to be pumped is in thermal communication with the material in the chamber.

Thus, by virtue of the invention, a cooling system is provided in which the pump automatically acts to pump coolant around the cooling circuit only when the temperature exceeds a predetermined value, without the need to use space in an engine compartment to accommodate a separate electrical controller or to provide any electrical connections to the clutch.

Preferably the material in the chamber expands when transforming from the first state to the second state.

Preferably the material is solid when in the first state and liquid when in the second state.

Preferably the material in the chamber of the temperature sensitive device is a wax.

Preferably the impeller has an internal hollow into which coolant to be pumped may pass. In this case, preferably, the chamber of the temperature sensitive device extends into this internal hollow.

Preferably the system includes a resilient biasing element which acts on at least one of the clutch members to urge the clutch members towards a separated configuration.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawing which shows part of a cooling system according to the first aspect of the invention.

Referring now the figure, there is shown part of a pump for pumping liquid coolant around a cooling circuit for an internal combustion engine, the

pump including a pump impeller 10 including an impeller shaft 12 which is mounted for rotation in a pump housing (a portion of which is shown at 13). The pump impeller 10 and housing 13 are of conventional design, and are adapted such that rotation of the impeller 10 in the housing about a longitudinal axis A of the impeller shaft 12 causes pumping of fluid in the housing from an inlet (not shown) to an outlet (not shown) provided in the pump housing 13.

The system is further provided with a drive shaft 14 which is connected to the engine (not shown) such that operation of the engine causes rotation of the drive shaft 14 about a longitudinal axis of the drive shaft 14, the drive shaft 14 being positioned such that its longitudinal axis generally coincides with the longitudinal axis A of the impeller shaft 12. The drive shaft 14 may be driven directly by the engine, or via a transmission such as gears or a belt drive.

Between a second end of the impeller shaft 12 and the drive shaft 14 there is provided a clutch 16 including first 18 and second 20 clutch members which are moveable into and out of engagement to connect and disconnect drive from the drive shaft 14 to the impeller shaft 12 respectively.

The first clutch member 18 has a generally cylindrical body 18a and a radially outwardly extending flange 18b which lies directly adjacent the impeller shaft 12. The first clutch member 18 is retained relative to the impeller shaft 12 by means of a retainer 32, a first end of which is fastened, in this example bolted, to a radially outwardly extending flange 36 provided at the second end of the impeller shaft 12. The retainer 32 has a side wall 32a which encloses a generally cylindrical space in which the first clutch member 18 is located, and a radially inwardly extending lip formation 32b which extends from the side wall 32a at a second end of the retainer 32. The lip formation 32b provides an aperture the diameter of which is sufficiently large to permit the body of the first clutch member 18 to pass therethrough but sufficiently small to prevent the flange of the first clutch member 18 from passing therethrough. Thus, whilst movement of the first clutch member 18 generally parallel to the

longitudinal axis of the impeller shaft 12 is permitted, the retainer 32 limits such movement and retains the first clutch member 18 adjacent the impeller shaft 12.

A resilient biasing element 34, which in this example is a generally helical compression spring, is located between the lip formation 32b of the retainer 32 and the radially outwardly extending flange at the first end of the first clutch member 18. The spring 34 is coiled around the cylindrical body 18a of the first clutch member 18 and acts to separate the flange and the lip formation 32b of the retainer until the first clutch member 18 engages with the impeller shaft 12. Thus, the spring 34 biases the first clutch member 18 towards a disengaged position in which it is spaced from the drive shaft 14.

The first clutch member 18 is moved against the biasing force of the spring 34 into and out of engagement with the second clutch member 20 by means of a temperature sensitive device 22 which is mounted for rotation with the impeller shaft 12 between the impeller shaft 12 and the first clutch member 18. The temperature sensitive device 22 includes a chamber 24 in which there is provided a wax 26, which over a first, lower, temperature range is solid, and which over a second, higher, temperature range is at least partially molten.

A generally cylindrical aperture is provided which extends between the chamber 24 to an end of the impeller shaft 12 adjacent to the first clutch member 18, and a generally cylindrical piston element 28 is located in this aperture. A first end 28a of the piston element 28 is received in a recess provided in the cylindrical body 18a of the first clutch member 18, and a second, opposite end 28b of the piston element 28 is located generally centrally of the chamber 24, and is surrounded by wax 26. The second end 28b of the piston element 28 is generally conical in shape. The fit between the piston element 28 and the aperture is such that permitted, but leakage of wax 26 from the chamber 24 through the aperture is substantially prevented.

The impeller shaft 12 is provided with a hollow portion 12a which extends to the end of the impeller shaft 12 adjacent the drive shaft 14 and which is in fluid communication with fluid within the pump housing 13. The chamber 24 of the temperature sensitive device extends into the hollow portion 12a, such that fluid in the hollow portion 12a is in thermal contact with wax 26 in the chamber 24.

The second clutch member 20 is simply a generally circular plate which is provided at an end of the drive shaft 14 adjacent to the impeller shaft.

Ends of the impeller shaft 12 and drive shaft 14 adjacent the first 18 and second 20 clutch members respectively are each supported for rotation about their longitudinal axes A in roller bearings 30 which are mounted in the pump housing 13.

The cooling system operates as follows.

When the temperature of the cooling fluid is below a predetermined value, the wax 26 is solid, and the biasing force of the spring 34 ensures that the first 18 and second 20 clutch members are not in contact, and hence drive is not transmitted from the drive shaft 14 to the impeller shaft 12. Thus, the pump does not operate even if the engine is running, and no energy is wasted pumping cooling fluid to/around an engine whose temperature is sufficiently low that additional cooling is not required.

During operation of the engine, the temperature of the engine gradually increases, and this results in a gradual increase in the temperature of the cooling fluid, including the cooling fluid in the hollow portion 12a of the impeller shaft 12. Heat is transferred from the cooling fluid in the hollow portion 12a of the impeller shaft 12, to the wax 26 in the chamber 24, and thus the temperature of the wax 26 increases. When the temperature of the wax 26 is sufficiently high, the wax 26 begins to melt, and expands on melting thus pushing the piston element 28 towards the first clutch member 18. The generally conical shape of the second end 28b of the piston element 28 may assist in this.

The piston element 28 thus exerts a force on the first clutch member 18, which pushes the first clutch member 18 against the biasing force of the spring 34 towards the second clutch member 20.

As the first and second clutch members 18, 20 engage, drive is transmitted from the drive shaft 14 to the impeller shaft 12, and the impeller shaft 12 rotates about its longitudinal axis A. Thus operation of the pump commences once the engine reaches a sufficiently high temperature that cooling is required.

When the temperature of the engine falls below the pre-determined value, for example after the engine is switched off, the wax 26 starts to solidify, and thus contracts. As the volume of the wax 26 in the chamber 24 decreases, the first clutch member 18 moves away from the second clutch member 20 under the restoring force of the spring 34. The impeller shaft 12 thus becomes disconnected from the drive shaft 14 and the speed of rotation of the pump impeller 10 decreases until operation of the pump ceases completely.